Michigan Stream Team White Paper
Whitewater Parks
May 2012

This white paper addresses issues associated with the development of whitewater parks (WWPs) in Michigan rivers. WWPs commonly use artificial rock or wood structures to augment natural whitewater features (steep, fast-flowing stream reaches, usually with rocky substrates) or to create new ones. Two WWPs have recently been constructed in Michigan; one in the Bear River in Petoskey and in the Argo Dam mill race on the Huron River in Ann Arbor. Several others have been proposed around the state. The WWP's noted above, like many installed in other states, consist of channel-spanning boulder drop structures that increase water velocity in short reaches by significantly reducing channel width and cross-sectional area and increasing local channel slope to vertical or near-vertical. These WWP structures, like all man-made in-stream structures, have the potential to negatively impact stream hydrology and hydraulics, sediment transport, channel morphology, and ecology, which collectively are known as stream function.

The primary goal of any stream construction project should be to maintain or restore stream function. Stream function is defined in the Clean Water Act as the physical, chemical and biological processes that occur in ecosystems. Stream function concerns specific to WWPs include:

- Accommodation of the stream's seasonally variable hydrology without triggering geomorphic instability in the channel or interfering with other stream functions such as organism passage.
- Conveyance of the stream's sediment, organic material, and woody debris loads.
- Connectivity for fish, macroinvertebrates and other aquatic organisms.
- Loss of interstitial habitats for fish and macroinvertebrates.
- Maintenance of hyporheic exchanges.
- Disruption of riparian habitat.
- Degradation of water quality.
- River dynamics.

Brief summaries of these stream function concerns follow.

WWP structures can potentially impact stream hydrology and hydraulics in several ways. Low-flow dams/weirs incorporated into certain WWP structures reduce channel width by up to 90 percent, creating velocity barriers to organism passage and potentially increasing shear stress on the downstream stream bed and banks. Further, Rosgen (2008) identified that placement of material in the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime. Rosgen categorized blockages of 30-50% as extensive, greater than 50% as dominating or human influenced where low-head dams, velocity control structures, etc. have an influence on the existing flow regime, such that significant channel adjustments occur.

These narrow weirs can also create stagnant pools that strand aquatic organisms and raise water temperature (Kohler and Hubert 1993). Certain WWP structures can eliminate shallow water habitats important for fish spawning and predator avoidance and isolate the stream channel from the adjacent floodplain, especially when the WWP includes above-channel rock “wings,” benches, terraces, or viewing platforms. Local changes in stream hydraulics can also interfere with sediment transport, organism passage, and hyporheic exchanges; see below.

Many of the channel spanning structures associated with WWPs are low head dams and have similar effects of what is thought of as more traditional low head dams (Ligon, et al. 1995; Shuman 1995; Ward and Stanford 1989). Dams interfere with sediment transport by creating sediment deposition zones in the pools between structures, which in turn may eliminate preferred fish habitat, interfere with downstream drifting of macroinvertebrates, and lower dissolved oxygen concentrations. WWP structures may also interfere with the transport of small and large organic materials. Organic material transport plays a crucial role in stream health, from fallen leaves that are food for macroinvertebrates to large woody debris that provides sediment retention in stream channels and cover for fish.

Aquatic organisms require a high degree of ecological connectivity for access to spawning habitats, genetic exchange, recruitment of new individuals from source populations, and minimization of predation due to stranding. WWPs can create passage barriers or stranding hazards for fish and other aquatic organisms due to a combination of high water velocities, inadequate water depths, high vertical drops, turbulence, and lack of interstitial spaces for resting cover.

Colorado Parks and Wildlife (CPW) is conducting ongoing studies monitoring fish passage through WWP structures. Physical measurements taken at various WWP sites suggest that these structures function as barriers to certain fish species and life stages for at least a portion of the annual hydrologic cycle. More conclusive results on the effect of WWPs on fish passage is forthcoming (Kondratieff 2012). The CPW has documented flow velocities exceeding 10 feet per second (fps) at various WWPs throughout Colorado during low flow periods. These flows are excessive and work to date has found they exclude most upstream fish passage.

This concern is further supported by studies conducted on the Truckee River in the State of Nevada by the U.S. Fish and Wildlife Service (USFWS). A condition of the permit issued for the Rock Whitewater Park on the Truckee called for fish passage, but unimpeded fish passage has not been documented to date so the structures will be modified (Cotter 2012).

Recently, the Michigan Department of Natural Resources (MDNR) measured velocities over WWP structures located in the mill race of Argo Dam, on the Huron River. Velocity measurements ranged from approximately 6 to 13 fps over the structures. Additional velocity measurements were collected independently by MDNR and USFWS at WWP structures on the Bear River in Michigan, and consistently exceeded 10 fps. Velocity measurements were taken at all sites well below bankfull discharges. These high velocities are greater than the known burst capabilities of most of the native fish species present in Michigan rivers (Bell 1986).

Many WWP installations eliminate interstitial habitats (the spaces between rocks) and hyporheic connections for macroinvertebrates and smaller fish when the structures are grouted or cemented together. Exchange of water between the stream channel and the hyporheic zone (the porous region beneath and beside a stream bed, where shallow groundwater and surface water mix), where it exists, is important to nutrient and carbon assimilation and temperature moderation, and therefore to macroinvertebrate productivity and general water quality. WWPs, especially those with structures whose rocks are held in place with grout, cement or similar materials, can interfere with or eliminate hyporheic exchange. For the reasons noted above grouting is a concern with the Nevada Department of Wildlife (NDOW) and USFWS.

The "social footprint" of WWPs is also an issue, in that modification of a channel to maximize whitewater recreation may preclude other recreational uses. Creel surveys conducted by the CPW indicated user conflict with anglers in areas where WWPs were developed in Colorado.

WWPs may include above-channel rock "wings," benches, terraces, or viewing platforms, which often displace riparian vegetation. Riparian vegetation contributes to the health of the river by providing shade, bank stabilization, allochthonous materials, large woody debris, and habitat for aquatic and terrestrial wildlife. Riparian vegetation also improves water quality by removing excess nutrients, preventing sedimentation from bank erosion, and lowering water temperature. Water quality is vital to the biological integrity of the river, and WWP structures may greatly increase the amount of rock in the stream or riparian corridor, which may increase thermal loading to the river.

Many of the concerns with WWPs noted by the Michigan Stream Team in this whitepaper are also shared with American Whitewater. *"American Whitewater's mission is to protect and restore our nation's whitewater resources and to enhance opportunities to enjoy them safely. Our members are predominantly conservation-oriented whitewater kayakers, canoeists, and rafters. Our river stewardship program focuses on restoring rivers impacted by hydropower dams, protecting free flowing rivers from environmental harm, and ensuring that river management supports sustainable river recreation" (Colburn 2012).*

Colburn notes in his paper that:

- All in-stream channel work should protect natural structure (bedrock, boulders, and native riparian vegetation) in the existing or new streambed area.

- Rivers are inherently dynamic systems and every structure placed in a stream will one day be disassembled and moved by the stream. This process should be a fundamental component of the design. Structures should be viewed as temporary, and be designed to accelerate or guide natural processes which will eventually take over. (Special note: It should be mentioned that some WWP designers claim that their structures are permanent and that they require less maintenance than natural channel design structures).

- Regardless of any special designation, rivers belong to all citizens and should be managed accordingly. Channel design elements that appear artificial can have detrimental aesthetic impacts that can last for a generation or more.

- Generally, channel designs that mimic natural streams will benefit the ecology of the stream – and they will be consistent with natural geomorphology. For example, if the design reach is in the middle of a popular Class II whitewater river, it would be appropriate to design Class II rather than Class V rapids in the reach.

Further, American Whitewater's policy on WWPs developed in May 2007 states that, "We feel that any modifications to an impaired river channel should be made with the utmost caution, care, and commitment. It is our policy that natural un-modified river channels should not be modified for the creation of whitewater parks."

In most rivers, a healthy system reflects a shifting mosaic of habitat types. Through the process of erosion, scour, deposition, migration, and avulsion, rivers must shift in order to introduce organics, deposit materials, replenish floodplains, and regenerate riparian vegetation. This process is important to the chemical and biological cycle of the river and development of the physical form of the river. The physical form that is able to transport the water, sediment and debris of the basin without severe erosion includes; access to the floodplain and a combination of river width, depth, cross-sectional area and slope with their naturally formed pool and riffle pattern (or step-pool pattern in straighter rivers).

Hardened banks are often used at bridge abutments, rock ramps and to protect infrastructure in urban areas. These hardened reaches should blend with natural, dynamically stable reaches where the channel is allowed to adjust to its flow and sediment regime. Reaches that are hardened need to be fixed permanently in place to insure structural stability to prevent undercut or blowouts from material being transported.

WWPs often use hard structures that incorporate grout, high step height over what is naturally stable, decrease cross sectional area and deflect flow into the bank which may lead to avulsion or bank erosion. Moreover, the use of grout and not designing for fixed stability results in the potential failure, resulting in large angular concrete particles that have the potential to significantly divert flows or create erosive conditions to adjacent properties. As noted previously by American Whitewater, WWP structures are designed to be temporary and not permanent structures.

Structures should not be constructed in river systems that are unstable until stability issues are addressed. Streams whose bankfull flow does not reach the floodplain are often unstable. Hardened bank stabilization structures (including energy reduction measures, flow deflection structures, slope stabilization and armoring) can cause adverse effects to stream evolution processes, riparian succession, habitat, and biological community interactions. Structures constructed in rivers for any reason must maintain the full bankfull cross sectional area of the channel so that the channel can adjust to the normal width, depth and slope patterns. Appropriate geomorphic data must be gathered and utilized to develop designs that create and/or maintain stream form and function.

Further, structures should not be constructed in rivers that are incised where bankfull flows can not reach the adjacent bankfull flats. This concentration of bankfull flow energy enhances lateral erosion and channel down-cutting. These unstable reaches can be made dynamically stable by providing new floodplains at the bankfull elevation and appropriate grade control structures that match normal stream slope and pool riffle spacing.

Although WWPs may provide other benefits, based on our review of the available research and the Michigan experience to date, WWP structures do not fully take into account stream function as defined in the Clean Water Act. Therefore, the Michigan Stream Team does not support any instream structures that do not fully address stream function and are not designed and installed with documented bankfull characteristics of width, depth, cross sectional area and slope.

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The views expressed in this working paper do not necessarily reflect the views or policy of the Michigan Stream Team member agencies.